Wild winters

Is the freakishly cold weather that hit Europe and the US in the last two years a fluke or a trend, asks Michael Le Page

LAST winter, Florida got so cold that torpid iguanas fell from trees, pythons froze to death, crops were damaged and corals in the seas around the Florida Keys died in greater numbers than ever recorded before. Further north, heavy snowstorms caused chaos across much of the US.

Across the pond in the UK, it got pretty nippy too – and it stayed cold for much longer than usual. The average temperature of the country in December 2010 was -1 °C, well below the long-term December average of 4.2 °C. It was the second coldest December in central England since records began back in 1659. Here too, heavy snowfalls brought cars, trains and planes to a standstill.

This extreme weather followed on from similar conditions in parts of Europe, the US and Asia the winter before (2009-10) and, to a lesser extent, the winter before that. So was this run of extreme winter weather a fluke, or can we expect more of the same?

More highs than lows

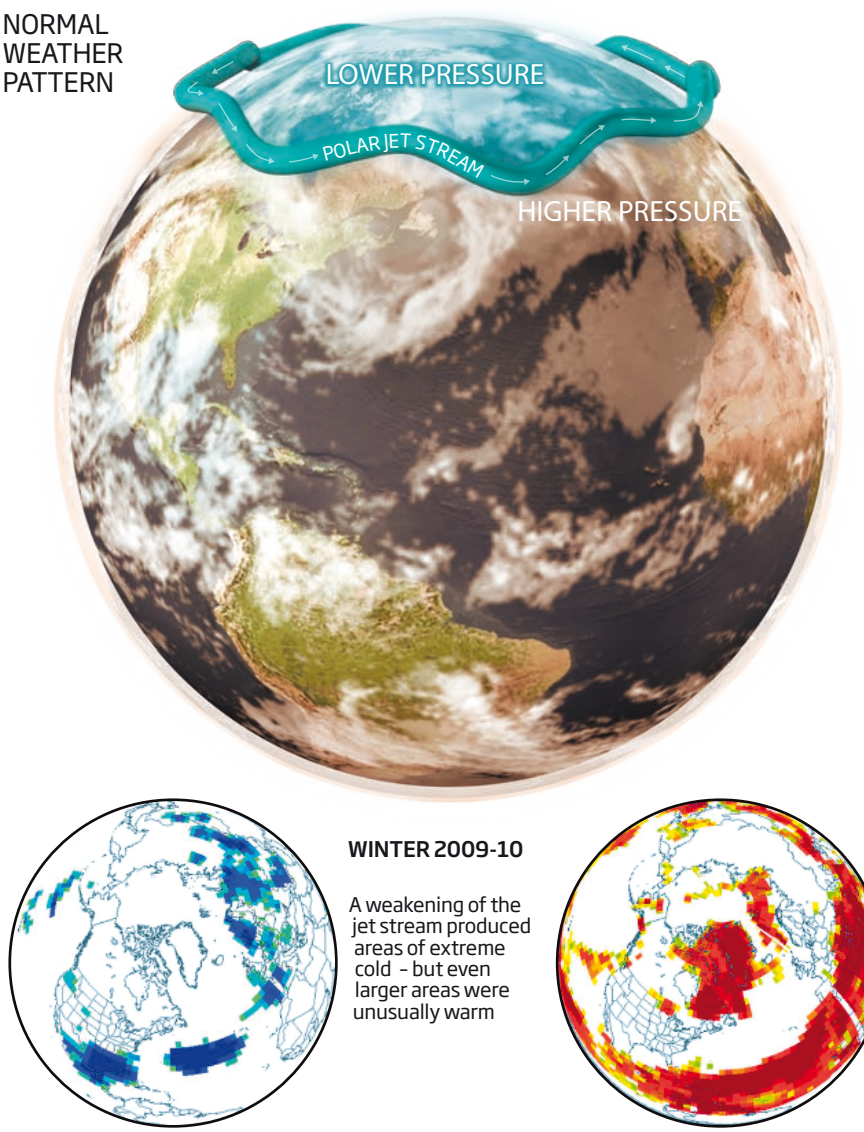
To get the full picture, we have to look at what happened across the northern hemisphere and how that compares with past winters. Parts of the hemisphere did have extended periods of cold weather, but from a historical perspective it was not that cold: few records for all-time lowest temperatures were set.

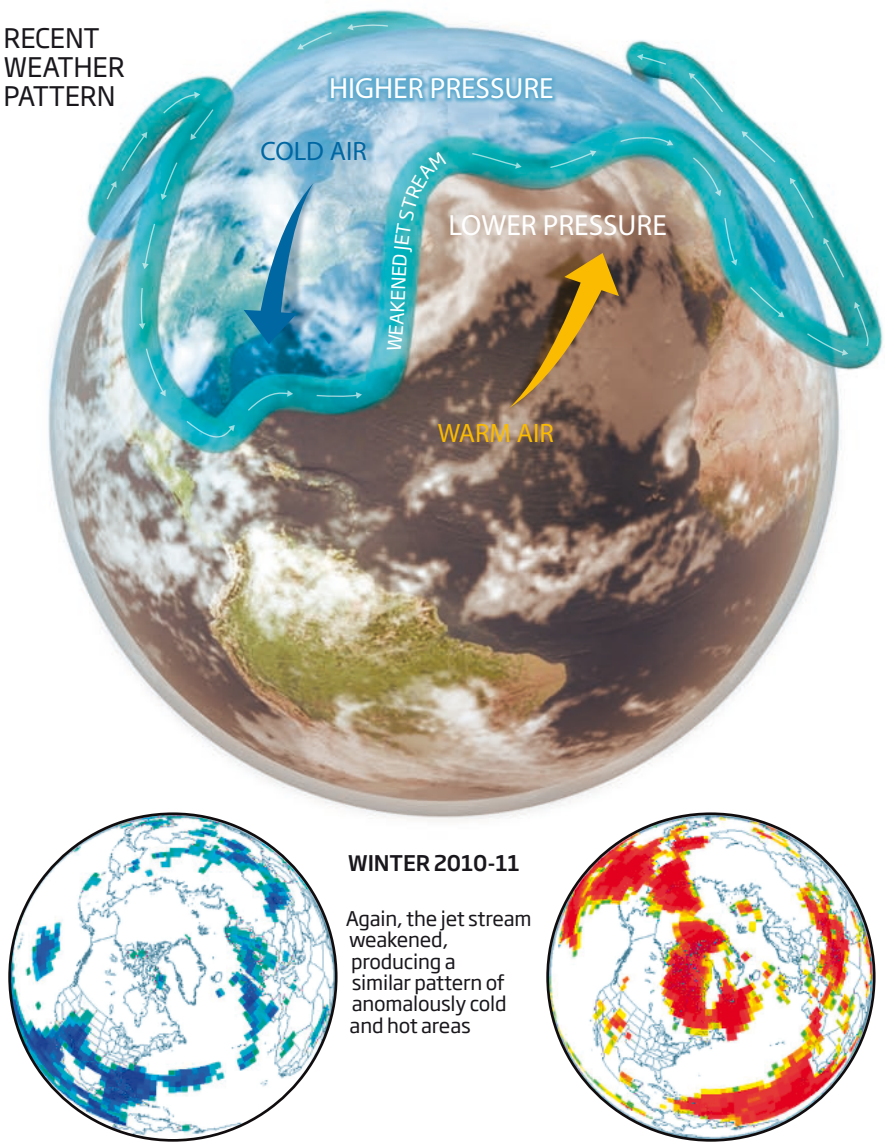
Meanwhile, in 2009, Canada had the warmest and driest winter since nationwide records began in 1948. Remember how the organisers of the Winter Olympics in Vancouver had to truck in snow? The average temperature over the country was 4 °C higher than normal, with some Arctic regions more than 6 °C over par.

In fact, during these two winters the northern hemisphere as a whole was warmer than the long-term average. More of it was unusually warm than was unusually cold, and the warm extremes were further away from the norm than the cold ones (*Geophysical Research Letters*, vol 38, p L17701).

Blowing hot and cold

During northern hemisphere winters, cold air is normally kept bottled up in the Arctic by fast-flowing westerly winds – the polar jet stream. When these winds weaken, cold air spills south in places while warm air flows north





WINTER 2010-11

Again, the jet stream weakened, producing a similar pattern of anomalously cold and hot areas

SOURCE: GURGUIS 2011, AMERICAN GEOPHYSICAL UNION

What caused these extremes of hot and cold? Jeff Masters of weather service Weather Underground likens the situation that prevailed at times during these winters to what happens when you leave the fridge door open: the cold air spills out into the kitchen, while inside the fridge it gets too warm.

Normally, cold Arctic air is hemmed in by strong westerly winds circling the globe near the pole, a configuration known as the polar vortex. The fastest of these winds form the jet stream, around 10 kilometres above us. The jet stream always follows a wavy path, moving closer to or away from the pole as it circles the globe, but when the winds weaken, these kinks grow much larger. This allows vast tongues of freezing air to spill southwards in places, while in others relatively warm air flows north towards the pole (see diagram, left). Depending on the position of the jet stream, this can bring either freezing Arctic blasts or

"It's like when you leave the fridge door open: cold air spills out, while inside the fridge it gets too warm"

balmy weather to countries such as the UK.

The polar vortex has always waxed and waned, but over the past two winters it was exceptionally weak for much of the time. The result was a pattern of atmospheric circulation known as "warm Arctic, cold continents". It is rare, but not unheard of: before these last two winters, the most recent occurrences were in 1936, 1963 and 1969.

Does that mean that natural variability was the cause of recent events? The short answer is that nobody knows for sure. "There are divided opinions," says James Overland of the Pacific Marine Environmental Laboratory in Seattle.

If it was just natural variability, we are unlikely to have more than another year or two of strange weather. Another suggestion is that there is a link with the recent extreme ›

low in solar activity. If so, since that solar minimum has now ended, things should also start to return to normal.

Overland, however, doesn't buy these ideas. He thinks there are a lot more snowy and cold winters to come. He points out that the Arctic is warming faster than anywhere else on Earth, and as the extent of summer sea ice falls, the Arctic Ocean is soaking up more heat during the summer and releasing it in autumn.

According to an analysis by Overland, finalised in October 2009 before the coldest of the recent winters began, this is affecting wind patterns above the Arctic and weakening the Arctic vortex (*Tellus*, vol 62, p 1). As the vortex weakens, it becomes increasingly likely that cold air will move south and produce anomalously cold winter weather.

Several other researchers have come to similar conclusions. In particular, Jennifer Francis of Rutgers University in New Brunswick, New Jersey, has been studying "reanalyses", which combine historical observations with the sort of computer models used by weather forecasters today to generate a complete picture of past weather. In as-yet unpublished work, she has found that, since the 1980s, the east-west component of the polar jet stream has slowed by around 15 per cent during autumn and winter, with the biggest drops occurring in the past few years.

The jet stream is driven by the difference in temperature between the high and low latitudes, but the rapid warming in the Arctic is weakening that temperature gradient, especially in autumn, she says. "I think what's happening at the surface is driving the changes at the upper level." A slowdown in the jet stream means it is more likely to develop the enormous kinks that let Arctic air spill south. What's more, these kinks move more slowly, making the weather they bring much more persistent.

They are also more likely to get stuck in one place for weeks at a time, Francis says. Such "blocking events" can lead to very extreme weather, such as the "Snowmageddon" blizzards in the US in February 2010 and the prolonged cold in the UK in December 2010.

There is some independent evidence to back Francis's ideas. A study published in November found that blocking events are becoming more frequent over the Atlantic (*Science*, vol 334, p 655).

Kinks in the jet stream can bring warm weather as well as cold, though, Francis points out. "It's not that we will have increasingly cold winters but more persistent conditions," she says. "This winter could be incredibly warm for a long time."

So the jury is still out, but a growing number of studies indicate that the atmospheric changes brought about by global warming are at least partly to blame for the past two extreme winters. If so, we could be in for a lot more unusual winter weather, with more extremes of both hot and cold. Hold on to your hat, because we could be in for a wild ride. ■

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WHAT'S WITH ALL THE SNOW?

Recent winters have brought not only extreme cold but also record snowfalls to many places across Europe, Asia and the US. But shouldn't we be seeing less snow if the world is getting warmer?

As always with matters climatological, things are not that simple.

Snow requires moist air, and warming is making the atmosphere wetter, which means more snow can fall at times. It also obviously has to be cold to snow, but once the temperature falls more than a few degrees below freezing heavy snowfall starts to become less likely, because very cold air is drier and less likely to rise and form clouds.

So as the world warms, the number of days during which it is cold enough to snow in a given area may decrease – but there could be more snowfall in areas that used to get so cold that heavy snow was rare.

PLAINPICTURE